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(54) CONDENSATION-FREE FREEZER DOOR ASSEMBLY

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No. OF CLAIMS 4

Abstract

A freezer door assembly with a viewing area and that requires no electric heating source to maintain the assembly free from condensation under standard conditions. The assembly includes inner and outer spaced parallel glass panes and a panel spaced between the panes, the panes and panel having confronting surfaces of which at least one is provided with coatings highly transmissive of visible light and highly reflective of long-wave infra-red radiation. The assembly includes an insulating frame at the edges of the panes, the frame having sufficiently low thermal conductivity as to in turn maintain outer surfaces of the frame and outer pane free from condensation under standard conditions.

CONDENSATION-FREE FREEZER DOOR ASSEMBLY

Technical Field

The present invention relates to freezer door assemblies of the type employed, for example, in supermarkets.

Background Art

Food freezers of the type normally employed in supermarkets commonly are provided with doors having viewing areas, e.g., windows through which a customer may view frozen food products. Freezers of this type may be upright freezers (in which the door opens on vertically aligned hinges), or horizontal (in which the door opens on horizontally aligned hinges).

Accepted industry design conditions for supermarket refrigeration equipment contemplates room temperature air (as in a supermarket) to be controlled in the summertime at 75° F (about 24 °C) and 55% relative humidity, and a freezer compartment to have a temperature of -12° F (about -24.4° C). Air at a temperature of 75° F (24° C) and 55% relative humidity has a dew point of approximately 58° F (14.4° C). If the exposed surfaces of the freezer door, that is, exterior surfaces of the frame or the window, drop below the dew point, undesirable condensation may form on these surfaces. Condensation on the window portion is particularly undesirable in that it becomes difficult or impossible for a customer to view frozen goods through the window. If the temperature of the exterior surfaces of the frame

or window drops below the freezing point, then frost is formed.

Only one practical solution to the condensation problem appears to have won favor in the industry. This solution requires electrical heating elements to be placed in the frame so that the exterior surface of the frame remains above the dew point temperature. Simularly, the window itself may be provided with an electrically conductive film heated by electrical resistance heating to raise the outer surface of the glass above the dew point. The heaters often are not carefully controlled, and exterior frame surfaces are often warm to the touch.

The amount of energy, overall, required to accomplish heating of a freezer door to prevent condensation is surprisingly large. One must consider not only the electrical energy required for heating the door, but also the energy required to dissipate such heat. For example, a supermarket may have thirty or more self-contained freezer units. If one assumes that each freezer includes a freezer door approximately two feet (0.61m.) in width and five feet (1.52m.) in heighth, and if one further assumes that the energy requirements for the glass window portion of the freezer is eight watts per square foot (0.093m^2) and that the frame of the door requires 10 watts per lineal foot (0.3m.) of perimeter, 220 watts of electrical energy are required to heat the freezer door. One may further assume that the freezer itself absorbs 70% of the heating energy, or 154 watts. If it is now further assumed that the ratio of the energy required to remove heat from the freezer is approximately three times the quantity of heat energy removed, then an additional 462 watts is required to remove the heat transferred to the freezer by the heated frame and window. The additional load on the freezer compressor (462 watts)

represents heat energy that will be dissipated to the interior of the supermarket. Employing the above ratio, 1386 watts are required to remove the additional heat from the supermarket. Since the freezer must be operated continuously throughout the year, the energy requirements of 220 watts and 462 watts set out above provides a total energy consumption during the year of about 6000 kilowatt hours for one freezer. Assuming that the air conditioning system of the supermarket is used only for about six months of each year, then the additional energy requirement for the air conditioning unit is approximately 6000 kilowatt hours per year. The total energy consumption of about 12,000 kilowatt hours per year, at an assumed cost of 5.5 cents per kilowatt hour, leads to a cost per door of approximately $660 U.S. per year. If thirty of such freezer doors are considered, the total direct and indirect cost of electrically heating the freezer doors rises to nearly $20,000 U.S.

The above example is not intended to be a factual analysis of any particular case, but is intended simply to illustrate the fact that the electrical resistance heating of freezer doors to prevent condensation is highly wasteful of energy. A freezer door which does not require additional energy input to avoid condensation hence is much to be desired.

Disclosure of Invention

The present invention relates to a glazed freezer door assembly having a viewing area and that requires no electrical heating source to maintain the assembly free from condensation. The assembly comprises inner and outer spaced, parallel glass panes, and a panel substantially transparent to visible light and positioned between and parallel to but spaced from the panes, the panes and panel defining two spaces therebetween. The panes and panel have confronting surfaces of which one or more (preferably two) surfaces, and

desirably surfaces facing separate spaces, are provided with thin coatings highly transmissive of visible light and highly reflective of long wave infra-red radiation, the panes and panel providing a U value (overall heat-transfer coefficient) of not more than about 0.20 Btu/(hr)(ft^2)(°F) (about 1.136 Watts/(m^2)(°K). The assembly includes an insulating frame that extends about and sealingly supports the panes and panel at their edges. The frame has an inwardly extending flange parallel to and along the outer surface of the outer pane, the flange having an inner edge defining a viewing area through the panes and panel, such area being at least about 80% of the area of the glass panes. The frame has sufficiently low thermal conductivity as to coact with the panes and panel assembly to maintain the exterior surface of the frame and the adjacent exterior glass pane surface at a temperature of not less than about 58°F(14.4° C) when the exterior surfaces of the frame and outer glass pane are exposed to air at 75° F (23.9° C) and 55% relative humidity, and the inner surface of the inner pane is exposed to air at -12° F (-24.4° C).

Brief Description of Drawings

Figure 1 is a perspective view of a freezer equipped with a door of the invention;

Figure 2 is a perspective view, partially broken-away, of the freezer door of Figure 1;

Figure 3 is a partially broken-away cross-sectional view taken along line 3-3 of Figure 1; and

Figure 4 is a broken-away, cross-sectional diagrammatic view of a spacer and associated structure, as shown also in Figure 3.

Best Mode for Carrying Out the Invention

Referring now to the drawing, a freezer door assembly of the invention is designated 10, and includes inner and outer, spaced, parallel glass panes (12 and 12.1) and a panel (14) that is substantially transparent

to visible light and that is positioned between and parallel to but spaced from the panes (12 and 12.1). The panes and panel define two spaces (16 and 16.1) therebetween.

As used herein, "inside" or "inner" refers to that portion of the assembly nearer the inside of the freezer with which the door is used, and the terms "outside", "outer" and "exterior" refer to the portion or portions of the assembly that are furthest from or face away from the freezer interior. The glass panes may be of any practical thickness, and thicknesses of about 1/8 to about 3/8ths of an inch (about 3.175 to about 9.525 mm.) are preferred. Preferably, the panes (12 and 12.1) are of tempered or heat-strengthened glass. The confronting surfaces of the glass panes preferably are spaced on the order of at least about 3/4 inches (about 19mm.) and the thus-described viewing area comprising the glass panes and panel may have an overall thickness of at least about one inch (25.4mm.).

The panel (14) may be of substantially any transparent material such as glass or plastic, but preferably is of polyester film having a thickness of from about .0005 to about 0.006 inches (about 0.013 to about 0.152mm.). Plastic film such as polyester film is preferred for the internal panel (14) because it is of light weight and because of the ease of manufacture of the assembly, which will be described more fully below.

The pane and panel assembly provides two exterior surfaces (12.2 and 12.3) and four internal surfaces of which two, (14.1 and 14.2) are provided by the panel with the remaining two (12.4 and 12.5) provided by the panes. At least one and preferably at least two of the four internal surfaces are provided with coatings "C" that are highly transmissive of visible light and highly reflective of long wave

infra-red radiation. Preferably, at least one coating confronts each of the two spaces (16 and 16.1), and if only one coating is used, this coating preferably confronts the air space (16) nearer the interior of the freezer. For ease of manufacture, it is preferred that the coatings be applied to each of the surfaces (14.1 and 14.2) of the panel (14), and the latter preferably is spaced an equal distance from the internal surfaces (12.4 and 12.5) of the glass panes. The panel 14 preferably also is provided with means such as a small orifice (14.3) permitting air or other gas to move between the two spaces (16 and 16.1).

Coatings of the type described that are highly transmissive of visible light and highly reflective of long wave infra-red radiation are known to the art, and have been popularly referred to as "heat mirrors". A number of such coatings are commercially available, and for the most part consist of two or more layers, the inner layer commonly being a metallic layer such as a vacuum-deposited gold, and an outer layer typically being an oxide of titanium. Coatings of this type have successfully been used as fog-preventive coatings for aircraft and automobile windshields, for ski goggles, etc. The coatings should be highly transmissive of visible light, that is, light of a wave length in the range of from about 0.3 to about 0.75 microns, and the transmissivity of such coatings should be in excess of 80% over a reasonably broad range of wave lengths of visible light. On the other hand, the coatings should be highly reflective of long wave infra-red radiation, that is, radiation having wave lengths in the range of from about five to about twenty microns. The reflectivity of such coatings to a reasonably broad band of wave lengths of long wave infra-red radiation should be at least about 85% and preferably greater than about 90%. The hemispherical emissivity of each

such coating should not exceed about 0.18.

Each pane is spaced at its edges from the panel by a spacer (18.6) that includes a generally hollow, elongated, tubular shape (18), typically of aluminum, having generally parallel, flat outer surfaces (18.4 and 18.5), as shown best in Figure 4. Thicknesses of the panel and coatings have, for clarity, been exaggerated in Figure 4. The tubular shape is provided with a passageway (18.1) in its interior, and the interior itself is provided with a desiccant such as a molecular sieve or silica gel (designated 18.2 in the drawing). Strips (18.3) of polyisobutylene are provided between the edges of the tubular shapes and the adjacent surfaces of the glass panes and panel, as shown best in Figures 3 and 4. The tubular shapes terminate short of the edges of the panes and panel, providing a recessed trough which in turn is filled with a rubber-like sealant (20) of a type commonly used in the art and which may be typified as Silicone Insulating Glass Sealant IGS 3204* (a product of the General Electric Company). About the edges of the thus prepared panel-pane assembly is provided a frame, including a gasket of rubber or of polyvinyl chloride or of other commonly used substances for this purpose, the gasket being shown as 21 in the drawing. About the frame gasket is assembled a rigid outer frame, designated generally as 22 in the drawing, the frame having a peripheral recess (22.1) shaped to receive the gasketed edge of the glass-panel assembly. A primary purpose of the gasket (21), as will now be evident, is to cushion the edges of the glass pane-panel assembly within the rigid frame.

The outer frame 22 is desirably of material having a low coefficient of thermal conductivity, i.e., not greater than about 0.7 Btu/(hr)(ft^2)(°F/in.), or about 0.1 Watt/(m)(°K). One such material is wood.

* Trademark

Frames of the assemblies of the invention preferably are made of polyurethane structural foam, however, the foam desirably having a closed-cell interior designated generally as "P", and a hard, solid skin designated generally as "S" in Figure 3. Polyurethane foam materials of this type are known to the art, and are typified by "Baydur" brand polyurethane structural foam, a trademarked commercial product of the Mobay Chemical Corporation. The coefficient of thermal conductivity for such material is 0.55 Btu/(hr)(ft^2)(°F/in), or about 0.08 Watts/(m)(°K). The frame is provided with at least one outer flange (22.2), and desirably with an inner flange (22.3), the flanges defining generally the walls of the peripheral recess (22.1) of the frame. The frame may be provided with an internal stiffening extrusion (22.4) of e.g., aluminum, of a type known to the art. The extrusion (22.4) tends to stiffen the frame structure, and may include a generally circular groove (22.5) to accept a torsion bar which ultimately is fastened to the jamb of the freezer compartment, the torsion bar providing the necessary springiness to the door so that when it is released, it will shut. The extrusion also provides an inner channel (22.6) into which may be inserted a magnetic gasket designated generally as (22.7). The large, hollow interior (22.8) of the aluminum extrusion is employed, as is known in the art, to accept corner keys (not shown). The aluminum extrusion (22.4), corner keys, the torsion bar spring system and the magnetic gasket are known to the art, and need not be described in further detail.

A typical freezer door assembly of the invention may be manufactured by first providing each of two equally dimensioned glass panes with peripheral elongated tubular shapes (18), typically of aluminum, attached by adherent polymer (e.g., polyisobutylene) strips (18.3), the tubular shapes being attached at corners by corner

keys of known design. To the exposed, generally flat surfaces (18.4 and 18.5) of the tubular shapes are adhered adherrent polymer (polyisobutylene) strips (18.3). A flexible plastic sheet having coatings "C" on both surfaces and defining the panel 14 is lightly stretched over the latter strips, care being taken to provide a tiny, desirably nearly imperceptible hole (14.3) in the panel near its edge. The panel should be stretched fairly tightly over the strips (18.3). The other pane is then mounted in the configuration shown in Figure 3, the exposed strip (18.3) carried by the tubular shape of the second pane coming into contact with the panel about its periphery and in opposed relationship to the first-mentioned adherrent polymer strip. A rapidly curing silicone sealant (20) is then provided about the periphery of the assembly to occupy the space defined by the confronting surfaces of the glass panes and the peripheral urfaces of the tubular shapes (18). When the silicone sealant is fully cured, the thus-described assembly is heated as a substantially sealed, integral unit by placing it in an oven at a temperature of from about 195° F (about 90.5° C) to about 250° F (about 121.1° C). It will be noted that the sealant is so chosen as to be able to withstand this range of temperatures without significant softening or degradation. The oven employed desirably is a forced air oven, and the entire assembly is raised to the oven temperature in a period of 5-20 minutes. The polyester film that is employed as a substrate for the panel (14) is a heat-shrinkable film; that is, it is film so oriented in its manufacture that upon further application of heat, it will tend to shrink in its plane. The oven temperature is selected so as to shrink the panel and to cause the same to be drawn tightly between the supporting spacers (18.6). The assembly is then removed from the oven and

allowed to cool slowly, (e.g., over a period of an hour or so), following which the panel (14) is found to be taut and flat and devoid of noticeable waves or wrinkles in its surface, and the coatings "C" are found to be substantially unimpaired from the standpoint of transparency to light and reflectivity of long-wave infra-red radiation.

It should be noted that the interior spaces (16 and 16.1) communicate with one another through the tiny orifice (14.3) formed in the panel so as to avoid pressure differentials across the panel. The spaces (16 and 16.1) may be air spaces or may be filled with a gas such as nitrogen. The desiccant carried by the tubular shapes (18) tends to adsorb water from the spaces (16 and 16.1), and hence condensation on the internal surfaces of the assembly is avoided.

The pane and panel assembly is enclosed within the gasket (21), as shown in the drawing, and to this assembly in turn is mounted the outer frame (22), the gasketed portion of the pane and panel assembly being received within the peripheral recess (22.1) of the outer frame. Hinges, handles, the magnetic gasket (22.7), a torsion bar and other desired hardware is then attached to the frame.

The inner surfaces of the freezer door assembly of the invention commonly will be exposed to the interior of a freezer maintained at approximately -12° F (-24.4° C). The outer surfaces of the assembly, under current design condition, will be exposed to air at approximately 75° F (23.9° C) and 55% relative humidity (herein sometimes referred to as "standard conditions"). To avoid condensation upon either the exterior surface (12.2) of the glass pane (12.1), or upon the exterior surface of the outer frame (22), such surfaces must be maintained at least slightly above 58° F (about 14.4° C). Heat loss from the outer surfaces of the frame (22) and pane (12.1)

occurs primarily at the edges of the unit, although of course some heat transfer occurs throughout the entire unit. It is believed that the coatings "C" tend to reduce heat loss from the outer surface (12.2) of the pane (12.1), and such radiation as is reflected from the coatings may be paritally absorbed by that pane to warm the same. The outer frame (22) is characterized by very low thermal conductivity. By combining the pane-panel assembly and the frame unit into a single freezer door structure, it has been found that the outer surface of the door (that is, the outer surfaces of the frame and pane (12.1)) are maintained above about 58° F (about 14.4° C) under standard conditions, and that as a result the freezer door of the invention requires no auxiliary heating system such as electric power to avoid condensation or frost formation. As pointed out above, the energy savings which can be realized with the freezer door assembly of the invention are significant.

Thus, the instant invention provides a freezer door assembly which is free of any external heating source, and which combines a glass pane and interior panel structure with a highly insulating peripheral frame in a manner preventing condensation from air at 75° F (23.9° C) and 55% R.H. on exterior surfaces of the door when the interior surfaces are exposed to a freezer compartment maintained at -12° F (-24.4° C).

While a preferred embodiment of the present invention has been described, it should be understood that various changes, adaptations, and modifications may be made therein without departing from the spirit of the invention and the scope of the appended claims.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A glazed freezer door assembly having a viewing area and requiring no electric heating source to maintain the assembly free from condensation, comprising

a) a viewing assembly including inner and outer spaced, parallel glass panes, and a panel substantially transparent to visible light and positioned between and parallel to but spaced from the panes, the panel having at least one surface bearing a substantially continuous thin coating highly transmissive of visible light and highly reflective of long-wave infra-red radiation, the viewing assembly having a U value not exceeding about 0.20 Btu/(hr)(ft^2)(°F); and

b) an insulating frame extending about and supporting the panes and panel at their edges and having a coefficient of thermal conductivity not greater than about 0.7 Btu/(hr)(ft^2)(°F/in.), and including a flange extending parallel to and along the outer surface of the outer pane; the viewing assembly and the frame each being sufficiently resistant to heat transfer and each coacting with the other so as to maintain outer surfaces of the outer pane and frame at a temperature above about 58°F when said outer surfaces are exposed to air at 75°F and 55% relative humidity, and the inner surface of the inner pane is exposed to air at -12°F.

2. The assembly of Claim 1 in which the panel comprises a sheet of polyester film heat shrunk between said panes to a taut, wrinkle-free condition.

3. The assembly of Claim 1 wherein the frame includes a rigid outer portion of a material having a coefficient of thermal conductivity not greater than about 0.7 Btu/(hr)(ft^2)(^{O}F/in.) and wherein said flange defines a viewing area not less than about 80% of the predetermined surface area of the panes.

4. A glazed freezer door assembly having a viewing area and requiring no electric heating source to maintain the assembly free from condensation, comprising

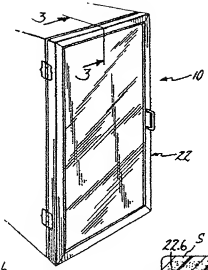
a) a viewing assembly including inner and outer spaced, parallel glass panes, and a panel parallel to but spaced from the panes and comprising a sheet of polyester film heat-shrunk between the panes to a taut, wrinkle-free condition, the panel bearing on each of its sides a thin coating highly transmissive of visible light and highly reflective of long-wave infrared radiation, the viewing assembly being characterized by a U value not exceeding about 0.20 Btu/(hr)(ft^2)(^{O}F);

b) an insulating frame including a rigid outer frame having a hard, dense outer skin and a cellular insulating interior and having a coefficient of thermal conductivity not exceeding about 0.7 Btu/(hr)(ft^2)(^{O}F/in.); the frame extending parallel to and along the outer surface of the outer pane;

the viewing assembly and the frame in which the viewing assembly

is supported each being sufficiently resistant to heat transfer and each coating with the other so as to maintain the outer surface of the outer pane and frame at a temperature above about 58°F when said outer surfaces are exposed to air at 75°F and 55% relative humidity, and the inner surface of the inner pane is exposed to air at -12°F.

Fig. 1



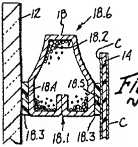
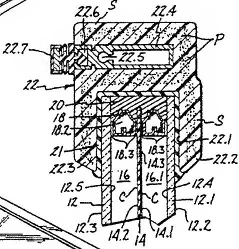


Fig. 4

Fig. 3



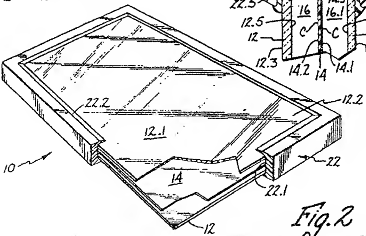


Fig. 2

Scott & Aylen